PATENT SPECIFICATION

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(19)

(54) A JACKETED PRESSURE VESSEL AND METHOD OF MANUFACTURING SAME

(71) We, SOCIETE CHIMIQUES DES CHARBONNAGES, a Body Corporate organised and existing under the laws of France, of Tour Aurore, Cedex 5, 92080 Paris La Defense, France and NATIONAL FORGE COMPANY, a corporation organised and existing under the laws of the State of Delaware, of Irvine, Warren County, Pennsylvania 16, 329, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Many pressure vessels or pressurized reactors used in the chemical process industries require that means be provided to either heat or cool the vessel. To satisfy this requirement, it has been conventional practice to weld a temperature control jacket to the reactor vessel thereby defining an annular space around the vessel through which a heat transfer fluid can be circulated.

Pressure vessels which operate at a relatively low pressure are usually made from welded steel plates. Generally, the welding of a temperature control jacket to such a vessel presents no difficulties since the vessel is made of a grade of steel which is suitable for welding.

However, in the case of vessels and reactors which contain high pressures, different constructions are employed in order to withstand safely the associated high operating pressure levels. For example, pressure vessels which contain pressures greater than 5,000 psi generally include walls of a substantial thickness, e.g. greater than 3 inches, and the materials which comprise the vessel wall are usually high strength, alloyed steels rather than plain carbon steels. As a result, the material used for the construction of such pressure vessels is not well suited for welding.

Increasingly, vessels for operating at high pressures, e.g. pressures greater than 5,000 psi, are manufactured by forging the entire body from a single high strength alloyed steel ingot, thus eliminating the need for any welding of the vessel structure. However, the necessity of a temperature control jacket still exists and it has been the practice to machine suitable projections on the outside of the vessel body and then weld a temperature control jacket to such projections. However, there are a number of problems associated with such a manufacturing technique and the resulting product. For example because the vessel material is not optimally suited for welding, extensive pre-welding preparation is required, such as buttering i.e. preliminarily coating with weld metal the surfaces to be welded before they are joined by welding, as well as carefully controlled preheating, in order to ensure that the weld is made at a specific elevated temperature. After the weld has been made, an equally extensive post weld heat treatment must be provided. Notwithstanding all these precautions, there is a significant tendency for weld cracks to form and such cracks, although seemingly local anomalies at the jacket welds, may grow and propagate into the main body of the vessel thereby causing a premature failure.

An object of the invention is to provide an effective solution to the problem of welding a temperature control jacket to a high pressure reactor vessel wherein the vessel is constructed of a material which is not well suited for welding.

According the the invention there is provided a pressure vessel in combination with a temperature control jacket disposed around the pressure vessel, said combination comprising

a) at least one ring of weldable material disposed around the pressure vessel, and said jacket being welded to the ring which is thereby an integral part of the jacket, and

b) means for radially compressing said ring.

Those skilled in the art to which this invention pertains will be aware of materials

which may be characterised as weldable, i.e. materials which may be welded without any substantial pre-weld or post weld treatments. Gererally, such materials are plain carbon steels having a carbon content not greater than approximately 0.35%.

The radial compressing means may be a second ring, shrink fitted about the first mentioned ring, or a belt wrapped around the first ring, or wire wrapped under tension about the first ring.

The first mentioned ring may be slidably mounted around the pressure vessel or shrink fitted thereon.

The wall of the pressure vessel will generally be a one piece, integral construction and may be provided with at least one outwardly directed flange about which the first ring is mounted. Also, the wall of the pressure vessel will generally be constructed of a high strength, alloyed metal which is not optimally suited for welding. In the event that a second ring is used to radially compress the first ring, the second ring will generally be constructed of a high strength material, for example a high strength, alloy steel similar to the material used to construct the wall of the pressure vessel.

By the practice of this invention, a temperature control jacket may readily be welded to the first ring. Additionally, any cracks which form as a result of welding the jacket to the first ring will not propagate into the wall of the pressure vessel. Also, since the first ring is not initially tensilely stressed to any substantial degree, this construction will not fail even if the pressure within the vessel is increased substantially beyond the normal, maximum operating pressure. Thus, with the construction formed in accordance with the invention, the pressure vessel may be tested at pressures substantially greater than the normal, maximum operating pressure of the vessel.

The invention will now be further described, by way of example with reference to the accompanying drawing in which:

Fig. 1 is a fragmentary view, in section, of one embodiment of the invention;

Fig. 2 is a sectional view taken along the section line 2—2 of Figure 1, and

Figs. 3 to 5 are fragmentary views, in section, showing alternate embodiments of the invention.

Referring to Fig. 1, there is shown a portion 10 of the wall of a high pressure reactor or vessel. Pressure vessels of the type with which this invention will be employed generally operate at pressures greater than 5000 psi and will have a wall thickness in the range of 3 inches or more. As previously indicated, in order safely to contain such high pressures the wall of such a vessel is often of unitary, integral construction, i.e. the pressure vessel is often forged from a single ingot of high strength alloy steel. While such materials provide adequate strength to resist high internal pressures within the vessel as previously indicated it is generally difficult to weld any material directly thereto, for example a temperature control jacket. Although such welding can be effected, substantial prewelding and post welding treatments are required. Additionally, as previously indicated, if a temperature control jacket is welded directly to the vessel body, any cracks developing as a result of the welding operation may propagate into the vessel wall and cause a premature failure.

With reference to Figs. 1 and 2 the problems noted above are substantially solved by providing a ring 12 of weldable steel disposed around the vessel wall 10.

This weldable carbon steel ring 12 is preferably disposed around an outwardly directed flange 14 on the wall of the pressure vessel. A temperature control jacket 18 is welded to the ring 12 as at 20.

Preferably, the ring 12 is initially slidably mounted around the flange 14. Thereafter, in the embodiment in Figs. 1 and 2, a second ring 16 is shrink fitted around the first ring 12. The second ring 16 is constructed of a high strength material, for example a high strength alloy steel material of the type used in the construction of the wall 10 of the pressure vessel. Because the second ring 16 is shrink fitted around the first ring 12, the second ring 16 functions to radially compress the first ring 12. As a result, the ring 12 is compressed against the outer surface of the flange 14 and a liquid tight seal is thereby provided between the flange 14 and the ring 12. When this construction has been obtained, it will be noted that the flange 14 and the first ring 12 are compressively stressed whereas the second ring 16 is tensilely stressed. This factor is of significance with respect to stresses which are imposed upon the first ring 12 when the vessel is operated or tested. Thus, when the pressure within the vessel is high there will be a tendency for radial dilation of the vessel. Such radial dilation will be restrained, in the area of the flange 14, by the shrink fitted ring 16. Since the shrink fitted ring 16 is constructed of a high strength, alloy material, it is well suited for resisting the stresses caused by radial dilation of the pressure vessel. More significantly, however, is the fact that the weldable carbon steel ring 12 is not subjected to substantial tensile stresses as a result of radial dilation of the vessel because such dilation is impeded by the shrink fitted outer ring 16. Thus, the first ring 12 is primarily subjected to bearing stresses. Such

a distribution of stresses is significant when compared to the situation which would exist if the second ring 16 were absent and the first ring 12 was shrink fitted around the flange 14. With such a construction, radial growth of the vessel would impose substantial tensile stresses in the ring 12. While the ring 12 may be designed adequately to resist such stresses at normal operating pressures, a difficulty is presented when the vessel is to be tested at a pressure of, for example, 1.5 times the normal maximum operating pressure. Thus, if a pressure vessel were tested at a pressure far in excess of its normal maximal operating pressure and if the first ring 12 was not surrounded by a second ring, the stresses in the ring 12 may exceed the yield point of the material from which the ring 12 is constructed. This result is particularly likely in view of the fact that the ring 12 is constructed of a weldable material (generally a plain carbon steel) and therefore the ring 12 will not possess the same strength characteristic as the high strength alloyed steel used in the construction of the vessel body.

Thus, it will be seen that the combination of the invention, as exemplified by the embodiment of Figs. 1 and 2, uniquely cooperates such that the ring 12 provides a weldable material to which the temperature control may be secured while the ring 16 retains the ring 12 in place and provides the desired sealing between the ring 12 and the flange 14. Additionally the second ring 12 absorbs stresses resulting from radial dilation of the vessel and thereby ensures that the ring 12 is subjected mainly to bearing stresses.

Although the stress distribution characteristics described above are significant, one of the most important aspects of this and other embodiments of the invention is the fact that weld cracks cannot propagate into the vessel wall. Thus, if any weld cracks should be formed when the temperature control jacket is welded to the ring 12, a growth of such cracks will not impair the integrity of the vessel wall. At worst, a leak of the low pressure temperature control fluid might occur. As such, it will be seen that this invention provides both an improved method for fabricating a jacketed high pressure reactor and the result of practicing this method is a jacketed, high pressure reactor having superior resistance to premature failure.

Referring to Fig. 3, there is shown another embodiment of the instant invention. Specifically, in the embodiment of Fig. 3 the central peripheral portion of the flange 14 has been undercut to provide the annular space 24. As a result, the bearing surface area between the flange 14 and the ring 12 is reduced with the consequent effect of increasing the bearing pressure between the ring 12 and the remaining portions of the flange 14. By the use of this construction, higher sealing pressures may readily be obtained between the ring 12 and the flange 14. In this connection, it should be noted that it is generally desirable that a high pressure seal of some type exist between the flange 14, the ring 12 and the ring 16 since it may be necessary to provide an aperture through these components. Such an aperture may be required to provide means for transporting a process fluid into or out of the reactor. Since the pressure of the proces fluid will be high, e.g. greater than 5000 psi, a positive, high pressure seal is required to ensure that the process fluid does not leak.

As previously indicated with respect to Figs. 1 and 2, in accordance with the invention the ring 12 is, in general, surrounded by means for radially compressing the ring 12. Figs. 4 and 5 illustrate alternate constructions for obtaining the desired radial compression of the ring 12. As shown at 28 in Fig. 4, the ring 12 may be wrapped with high strength tensioned steel wire. In the event that this approach is utilized, a retaining wall 30 for the wire may be provided.

Alternatively, as shown at 32 in Fig. 5, the ring 12 may be wrapped with high strength, tensioned steel bands which thereby provide the desired stress to radially compress the ring 12.

As suggested by the phantom representation at 38 in Figs. 4 and 5, a portion of the flange 14 may be relieved, i.e. removed, to increase the bearing stress between the flange 14 and the ring 12.

Although a number of embodiments of this invention have been disclosed, it is expected that those skilled in this art may perceive other embodiments which are nevertheless within the scope of this invention as defined by the claims appended hereto. As an example of another such embodiment, rather than having the ring 12 initially, slidably mounted on the vessel, a light shrink fit may be used to hold the ring 12 in place until it is surrounded by radial compression means. The phrase "light shrink fit" is used to mean a shrink fit sufficient to hold the ring 12 in place but not so great as to induce in the ring 12 tensile stresses of such magnitude that the yield point of the ring would be exceeded during testing or use the vessel.

WHAT WE CLAIM IS :—

1. A pressure vessel in combination with a temperature control jacket disposed around the pressure vessel, said combination comprising

a) at least one ring of weldable material disposed around the pressure vessel, and

said jacket being welded to the ring which is thereby an integral part of the jacket, and

b) means for radially compressing said ring.

2. The combination as claimed in claim 1 wherein the wall of the pressure vessel is of one piece, integral construction.

3. The combination as claimed in claim 1 wherein said compressing means comprise wire wrapped under tension around said ring.

4. The combination as claimed in claim 3 wherein the wall of the pressure vessel includes an outwardly directed flange integral with said wall, and the ring is disposed around said flange.

5. The combination as claimed in claim 4 wherein the central peripheral portion of said flange is undercut.

6. The combination as claimed in claim 4 wherein said ring is shrink fitted onto said flange.

7. The combination as claimed in claim 1 wherein said compressing means is belt wrapped around said ring.

8. The combination as claimed in claim 7 wherein the wall of the pressure vessel includes an outwardly directed flange integral with said wall, and the ring is disposed around said flange.

9. The combination as claimed in claim 8 wherein the central peripheral portion of said flange is undercut.

10. The combination as claimed in claim 8 wherein said ring is shrink fitted onto said flange.

11. The combination as claimed in claim 1 wherein said compressing means is a second ring shrink fitted around the first mentioned ring.

12. The combination as claimed in claim 11 wherein the wall of the pressure vessel includes an outwardly directed flange integral with said wall, and the ring is disposed around said flange.

13. The combination as claimed in claim 12 wherein the central peripheral portion of said flange is undercut.

14. The combination as claimed in claim 12 wherein said first ring is shrink fitted around said flange.

15. A pressure vessel having a wall of a one piece, integral construction, and a temperature control jacket disposed around the pressure vessel, the combination of the pressure vessel and jacket comprising

a) at least one ring of weldable metal disposed around the pressure vessel, and said jacket being welded to the ring which is thereby an integral part of the jacket, and

b) means surrounding said ring for radially compressing the ring.

16. The combination as claimed in claim 15 wherein said compressing means is a second ring shrink fitted around the first mentioned ring.

17. The combination as claimed in claim 16 wherein said first ring is shrink fitted around the pressure vessel.

18. The combination as claimed in claim 17 wherein said first ring is shrink fitted around an outwardly directed flange on the pressure vessel.

19. A method of manufacturing a jacketed high pressure reactor vessel having a unitary wall constructed of an alloy steel, comprising

a) disposing around the wall of the pressure vessel at least one ring of weldable steel;

b) surrounding the ring with means for radially compressing said ring; and

c) welding the jacket to the ring which is thereby an integral part of the jacket.

20. The method as claimed in claim 19 wherein the surrounding of the ring with means for radially compressing the ring comprises shrink fitting a second ring around the first mentioned ring.

21. A pressure vessel having a temperature control jacket, substantially as hereinbefore described wih reference to the accompanying drawing.

22. A method of manufacturing a jacketed high pressure reactor vessel having a unitary wall constructed of an alloy steel, substantially as hereinbefore described with reference to the accompanying drawing.

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1514606 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG.1

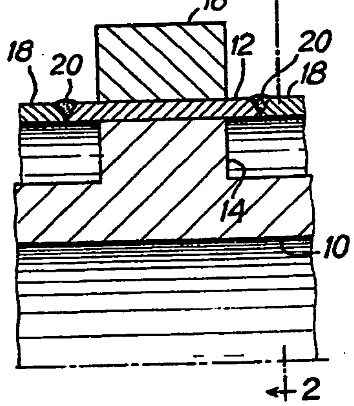


FIG.2

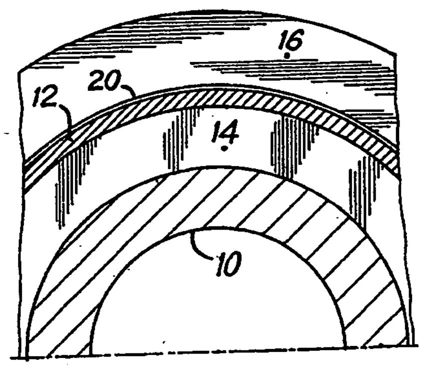


FIG.3

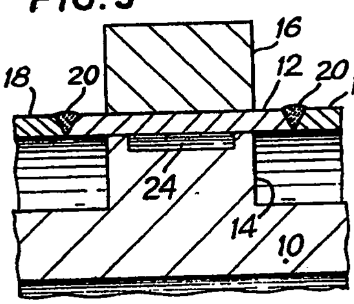
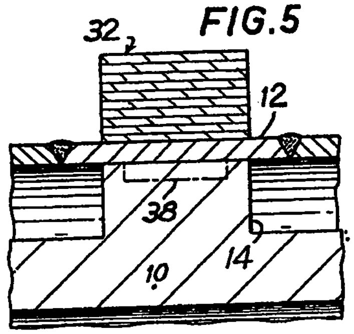


FIG.5



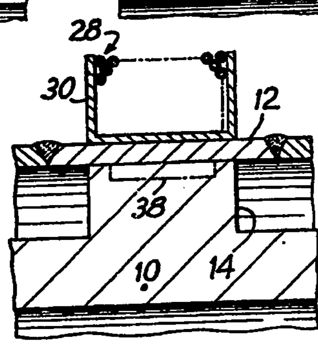


FIG.4